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Response of Cotton (*Gossypium hirsutum* L.) to Different Conservation Agricultural Practices under Rainfed Situations

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A B S T R A C T

Field experiments were conducted on a fixed site of Conservation Agriculture Project at main Agricultural Research Station, University of Agricultural Sciences, Dharwad, during 2014-15 and 2015-16 to study the effect of conservation tillage and land configuration on growth and yield of cotton under rainfed situations. The experimental findings showed that, all the conservation tillage systems *viz*, No tillage with broad bed and furrow (BBF) and crop residues retained on the surface, reduced tillage with BBF and incorporation of crop residues, no tillage with crop residues retained on the surface and reduced tillage with flat bed with incorporation of crop residues recorded significantly higher growth and yield parameters as compared to conventional tillage systems. No tillage with broad bed and furrow (BBF) and crop residues retained on the surface and reduced tillage with BBF and incorporation of crop residues produced significantly higher kapas weight (150.78 and 150.72 g plant^{-1}, respectively) and seed cotton yield (1,756 and 1,743 kg ha^{-1}, respectively) over conventional tillage with incorporation of crop residues (145.42 g plant^{-1} and 1,572 kg ha^{-1}, respectively) and conventional tillage without crop residues (139.26 g plant^{-1} and 1,324 kg ha^{-1}, respectively).

Introduction

Cotton (*Gossypiumhirsutum* L.) is the most important commercial crop of India cultivated in an area of 12.65 million ha with a production of 40 million bales of lint. Cotton contributes to 80 per cent of the raw material to the textile industry and provides employment to nearly 60 million people. India ranks first in area and second in global cotton production. Actual yield levels are low due to poor soil fertility (Bhatt and Nathu, 1986).In many regions of India, expensive and energy consuming tillage operations, declining soil fertility and soil moisture limitation are major constraint for agricultural crop production, In rainy *(kharif)*season crops are dependent of rainwater while winter *(rabi)* season crops are dependent on conserved soil moisture (Dhar *et al.,* 2008).Tillage methods affect the sustainable resources through its influence on soil properties, crop growth and the use of excessive and un-necessary tillage operations is often harmful to soil (Nazeer *et al.*, 2012). The yield increase was correlated with increase in water contents in soil due to decrease in evaporation (Chuadhary *et al.*, 2012). The conservation tillage practices, developed mainly for large scale mechanized agriculture need to be adopted for rainfed

pulses in India (Kumar *et al.,* 2006), which are systems of managing crop residue on the soil surface or incorporation with minimum or no tillage (Unger and McCalla, 1980), are crucial in efficiently saving more precipitation for crop production (Halvorson *et al.,* 2000).In cases where soil moisture limits plant growth, conservation tillage has been reported to produce crop yields similar or higher than conventional tillage(Tessier *et al.,* 2008). The use of less tillage with increase residue preservation enhance water conservation and other benefits like decreasing soil erosion and increase organic matter content resulting in improved soil physical properties (Blanco and Lal, 2008). It is hypothesized that, cotton crop needs optimum soil moisture for better boll development hence, residual soil moisture which is conserved from conservation agricultural practices would enhance crop as well as water productivity. In this view the present study was planned to investigate the effect of different conservation agricultural practices on growth and yield of cotton under rainfed situations

Materials and Methods

Field experiments were carried out in the fixed experiment site of Conservation Agriculture Project plot at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad (Karnataka) during the year 2014-15 and 2015-16 on *verticinceptisols* with neutral pH (7.4), soil organic carbon (0.52%), available nitrogen (261.58 kg ha^{-1}), available phosphorus (32.26 kg ha^{-1}) and available potassium (307.20 kg ha^{-1}). The region receives an average annual rainfall of 711.44 mm, which was well distributed from April to November.

During 2014 the total annual rainfall received was about 962.4 mm which was 34 per cent more than normal. The delayed onset of monsoon during *kharif* (July) resulted in delayed sowing of *kharif* crops. The rainfall received during *rabi* season mainly during October and November was 152.2 mm and the October rainfall was 17 per cent less than the normal. However the rainfall of 48.8 mm received in November which was 15 per cent higher than the normal helped to get good crop stand and optimum yield. The highest and lowest mean monthly maximum temperatures recorded were 37.8 ^{0}C and 27 ^{0}C, respectively during the months of May and August, respectively. Whereas mean monthly minimum temperature was ranged from 14.5 ^{0}C (December) to 21.6 ^{0}C (June).

Mean monthly maximum relative humidity of 89 per cent and mean monthly minimum relative humidity of 42 per cent were observed during the month of June and March, respectively. During 2015, the total rainfall received was 716.2 mm which was 3 percent less than the normal rainfall. The crops were sown early in *kharif* (June) as compared to first year. In June and October, there was 160.2 and 179.8 mm rainfall, respectively. During crop growth period (July, August and September) there was less rainfall received (42.8 mm, 34.4 mm and 22.4 mm, respectively) and it was about 73, 66 and 79 percent lesser than the normal rainfall hence, one protective irrigation was given through sprinkler on 18th of August. Dry spells during August, September and October affected the growth and development of the crop during early stages of crop which resulted in lower productivity. The highest and lowest mean monthly maximum temperatures observed were 35.1^{0}C and 28.6 ^{0}C, respectively during the month of April and January, respectively. Similarly, highest and lowest mean monthly minimum temperature were recorded in the month of May (21.9 ^{0}C) and January (13.3 ^{0}C). Mean monthly maximum relative humidity of 80% and monthly maximum relative humidity of 40% was observed during the month of June and February, respectively.

The experiment was laid out in strip block design and replicated thrice. Cotton (*Bt* hybrid) was taken under six different tillage systems, viz., CT_1: No tillage with BBF and crop residues retained on the surface, CT_2: Reduced tillage with BBF and incorporation of crop residues, CT_3: No tillage with flatbed and crop residues retained on the surface, CT_4: reduced tillage with flatbed and incorporation of crop residues, CT_5: Conventional tillage with incorporation of crop residues and CT_6: Conventional tillage without crop residues.

The experiment was initiated during 2013-14 and conservation tillage plots were permanently maintained with bigger plot size of 15 m width and 9 m length. In convention plots, the land was ploughed with mould board plough once, cultivated and harrowed and soil was brought to fine tilth.

In conservation tillage plots, minimum tillage for crop residue incorporation with rotovater two months before sowing and no tillage plots maintained with crop residue shredding and retention on the surface during 1st week of April, till than residues were maintained on the surface. Cotton was dibbled in the spacing of 90 cm x 30 cm. After every 6 rows (180 cm) a row was skipped for opening furrow (30 cm) which help to layout Broad Bed and Furrows (BBF) with 180cm bed and 30 cm furrow immediately after sowing of the crop. All the recommended package of practices for cotton were followed to raise the healthy crops.

Paraquat a contact herbicide was sprayed to kill the established weeds 10 days before sowing. The crop was weed free up to 30 days by pre-emergence application of pendimethalin and later weeds were managed by post emergence application of quizalofop ethyl 5% EC at 40 DAS with the help of hand operated knapsack sprayer.

Five cotton representative plants were sampled at harvest to record plant height (cm), monopodia and sympodia branches plant^{-1}, total dry matter production (g plant^{-1}) and yield attributes viz., total number of bolls plant^{-1}, kapas weight (g plant^{-1}) and mean boll weight (g). Whereas, leaf area (dm^2 plant^{-1}) and leaf area index (LAI) of cotton were taken at 120 DAS and harvesting of seed cotton was done in two pickings from the net plot for computing kapas yield ha^{-1}.

The data obtained from various studies were statistically analyzed following the procedure as described by Gomez and Gomez (1984). The level of significance used in 'F' tests was P = 5% and the mean values were separately subjected to Duncan's Multiple Range Test (DMRT) using the corresponding error mean sum of squares and degrees of freedom values under M–STAT - C program.

Results and Discussion

Growth and morphological traits

Two years pooled data showed that, at harvest all the conservation tillage practices such as no tillage with BBF and crop residue retained on the surface (CT_1), reduced tillage with BBF and incorporation of crop residue (CT_2), no tillage with flat bed with crop residue retained on the surface (CT_3), and reduced tillage with flat bed with incorporation of crop residue (CT_4), recorded significantly higher plant height (149.31, 149.03, 146.53 and 147.05 cm, respectively), number of monopodia plant^{-1} (3.17, 3.17, 3.00 and 3.07, respectively), number of sympodia plant^{-1} (21.50, 21.17, 20.80 and 21.07, respectively) and total dry matter production (176.04, 175.82, 170.38 and 172.15 g plant^{-1}, respectively) as compared to convention tillage without crop residue (CT_6, 133.74 cm, 2.70, 17.87 and 159.30, g plant^{-1}, respectively). However, they were on par with

conventional tillage with crop residue incorporation. Whereas, no tillage with BBF and crop residue retained on the surface (CT_1) and reduced tillage with BBF and incorporation of crop residue (CT_2) recorded significantly higher leaf area (156.04 and 156.71 dm^2 $plant^{-1}$, respectively) and leaf area index (2.89 and 2.90, respectively) at 120 DAS over other tillage systems (Table 1 and 2). This could be due to the compound effects of many factors, namely additional nutrient, improved soil physical properties, water regimes, better water extraction, aeration and resource use rather than conventional tillage (Unger and Jones, 1998). This might be due to optimum availability of nutrients through organic crop residues and favorable soil environment through balanced soil moisture which enhanced nutrient availability, rate of photosynthesis and consequently led to better vegetative growth. Improved soil structure and nutrient status of the soil by crop residue and adequate moisture availability during dry spell through BBF attributed to higher growth parameters (Ajayi, 2015).

Yield and yield attributing traits

Two years pooled data showed that, no tillage with broad bed and furrow (BBF) and crop residues retained on the surface (CT_1), reduced tillage with BBF and incorporation of crop residues (CT_2), no tillage with crop residues retained on the surface (CT_3) and reduced tillage with flat bed with incorporation of crop residues (CT_4) recorded significantly higher seed cotton yield (1,756, 1,743, 1,623 and 1,667 kg ha^{-1}, respectively) as compared to conventional tillage with crop residues incorporation (CT_5, 1,572 kg ha^{-1}) and conventional tillage without crop residues (CT_6, 1,324 kg ha^{-1}).With respect to stalk yield conventional tillage without crop residues (CT_6) recorded significantly lower stalk yield (2,584 kg ha^{-1}) over other tillage systems (Table 4).

Higher seed cotton yield is governed by number of factors having direct and indirect influence. The main factors which have direct bearing on seed cotton yield are total number of bolls $plant^{-1}$, mean boll weight and kapas weight $plant^{-1}$. The growth and morphological traits like plant height, sympodial branches $plant^{-1}$, leaf area, leaf area index and total dry matter production $plant^{-1}$ had positively influenced the above yield traits and further they had on seed cotton yield. The results obtained in the investigation are in close accordance with the finding of Blaise (2011), who reported that in three years field experiment in cotton, reduced tillage with green manuring and mulching of weed biomass produced significantly higher plant height, more number of sympodial branches, more number of bolls m^{-2} and higher seed cotton yield over conventional tillage. Similarly, no tillage with BBF and crop residues retained on the surface (CT_1), reduced tillage with BBF and incorporation of crop residues (CT_2), no tillage with flat bed with crop residues retained on the surface (CT_3) and conservation tillage with flatbed with incorporation of crop residue (CT_4) recorded significantly more number of total bolls $plant^{-1}$ (46.33, 46.07, 43.40 and 44.37, respectively) over conventional tillage without crop residue (CT_6, 40.50) and they were on par with conventional tillage with crop residues incorporation (43.67). Whereas, mean boll weight was significantly higher (5.17 g) in reduced tillage with BBF and incorporation of crop residue (CT_2) as compared to conventional tillage with crop residue incorporation (CT_5, 4.93 g) and conventional tillage without crop residue (CT_6,4.68 g) and these were on par with, no tillage with BBF and crop residues retained on the surface (CT_1, 5.10 g), no tillage with flatbed with crop residues retained on the surface (CT_3, 5.22 g) and reduced tillage with flatbed with incorporation of crop residue (CT_4, 5.21 g).

Table.1 Growth parameters of cotton at harvest as influenced by different conservation tillage practices

Tillage systems (CT)	Plant height (cm)			Number of monopodia plant^{-1}			Number of sympodia plant^{-1}			Leaf area (dm^2 plant^{-1}) at 120 DAS		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
CT_1 - No tillage with BBF and crop residues retained on the surface	159.62a	139.01a	149.31a	3.27a	3.07a	3.17a	24.80a	18.20a	21.50a	171.64a	140.44ab	156.04a
CT_2 - Reduced tillage with BBF and incorporation of crop residues	159.21a	138.85a	149.03a	3.20a	3.13a	3.17a	24.33a	18.00a	21.17a	170.85a	142.57a	156.71a
CT_3- No tillage with flat bed with crop residues retained on the surface	159.92a	133.14a	146.53a	3.20a	2.80bc	3.00a	25.00a	16.60a	20.80ab	170.85a	131.17c	151.01b
CT_4- Reduced tillage with flat bed with incorporation of crop residues	158.97a	135.13a	147.05a	3.13a	3.00ab	3.07a	24.73a	17.40a	21.07ab	169.62a	132.32bc	150.97b
CT_5- Conventional tillage with crop residues incorporation	151.52ab	135.55a	143.54ab	3.13a	2.93a-c	3.03a	22.07ab	17.47a	19.77b	162.53ab	133.08bc	147.81b
CT_6- Conventional tillage without crop residues	146.63b	120.85b	133.74b	2.67b	2.73c	2.70b	21.13b	14.60b	17.87c	153.63b	128.15c	140.89c
S.Em. ±	**2.71**	**3.50**	**2.50**	**0.10**	**0.08**	**0.06**	**0.89**	**0.55**	**0.41**	**2.91**	**2.56**	**1.30**
F test **5 %**	*	*	*	*	*	*	*	*	*	*	*	*

DAS: Days after sowing, *: Significant at 5 %

Table.2 Growth and yield parameters of cotton at harvest as influenced by different conservation tillage practices

Tillage systems (CT)	Leaf area index at 120 DAS			Total dry matter production (g plant^{-1})			Good opened bolls per plant^{-1} (GOB)			Bad opened bolls plant^{-1} (BOB)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
CT_1 - No tillage with BBF and crop residues retained on the surface	3.18a	2.60ab	2.89a	186.50a	165.59a	176.04a	44.87a	40.07a	42.47a	3.20bc	4.53bc	3.87bc
CT_2 - Reduced tillage with BBF and incorporation of crop residues	3.16a	2.64a	2.90a	185.64a	165.99a	175.82a	45.07a	39.87a	42.47a	3.00c	4.20c	3.60c
CT_3- No tillage with flat bed with crop residues retained on the surface	3.16a	2.43c	2.80b	182.82a	157.95a	170.38a	43.47ab	35.47bc	39.47a	3.33bc	4.53bc	3.93bc
CT_4- Reduced tillage with flat bed with incorporation of crop residues	3.14a	2.45bc	2.80b	183.68a	160.61a	172.15a	42.67ab	38.47ab	40.57a	3.20bc	4.40bc	3.80bc
CT_5- Conventional tillage with crop residues incorporation	3.01ab	2.46bc	2.74b	180.41a	161.18a	170.80a	40.07bc	38.73ab	39.40ab	3.67ab	4.87ab	4.27ab
CT_6- Conventional tillage without crop residues	2.85b	2.37c	2.61c	171.83b	146.76b	159.30b	38.20c	33.73c	35.97b	3.93a	5.13a	4.53a
S.Em. ±	**0.05**	**0.05**	**0.02**	**2.05**	**2.75**	**1.65**	**1.32**	**1.27**	**0.92**	**0.16**	**0.15**	**0.16**
F test **5 %**	*	*	*	*	*	*	*	*	*	*	*	*

DAS: Days after sowing, *: Significant at 5 %

Table.3 Yield components of cotton as influenced by different conservation tillage practices

Tillage systems (CT)	Total number of bolls plant^{-1}			Mean boll weight (g)			Seed index (%)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
CT_1 - No tillage with BBF and crop residues retained on the surface	48.07a	44.60a	46.33a	5.32a-c	4.75a	5.10ab	12.40a	12.23a	12.32a
CT_2 - Reduced tillage with BBF and incorporation of crop residues	48.07a	44.07ab	46.07a	5.59ab	4.90a	5.38a	12.55a	12.24a	12.22a
CT_3 - No tillage with flat bed with crop residues retained on the surface	46.80a	40.00bc	43.40ab	5.65a	4.70a	5.22ab	12.52a	11.99a	12.25a
CT_4 - Reduced tillage with flat bed with incorporation of crop residues	45.87ab	42.87a-c	44.37a	5.58ab	4.73a	5.21ab	12.58a	12.24a	12.30a
CT_5 - Conventional tillage with crop residues incorporation	43.73ab	43.60ab	43.67ab	5.18bc	4.66a	4.93bc	12.61a	11.73a	12.01a
CT_6 - Conventional tillage without crop residues	42.13b	38.87c	40.50b	4.98c	4.20b	4.68c	12.22a	11.64a	11.95a
S.Em. ±	**1.29**	**1.26**	**0.96**	**0.13**	**0.12**	**1.10**	**0.17**	**0.24**	**0.18**
F test **5 %**	*	*	*	*	*	*	NS	NS	NS

NS: Non significant, *: Significant at 5 %

Table.4 Yield and yield components of cotton as influenced by different conservation tillage practices

Tillage systems (T)	Kapas weight (g plant^{-1})			Seed cotton yield (kg ha^{-1})			Stalk yield (kg ha^{-1})		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
CT_1 - No tillage with BBF and crop residues retained on the surface	155.52a	146.05a	150.78a	1,878ab	1,635a	1,756a	3,288a	2,728a	3,008a
CT_2 - Reduced tillage with BBF and incorporation of crop residues	155.79a	145.65a	150.72a	1,862ab	1,624a	1,743a	3,318a	2,757a	3,038a
CT_3 - No tillage with flat bed with crop residues retained on the surface	155.32a	140.28ab	147.80a	1,889a	1,356ab	1,623ab	3,372a	2,536a	2,954a
CT_4 - Reduced tillage with flat bed with incorporation of crop residues	155.78a	142.06a	148.92a	1,847ab	1,487ab	1,667ab	3,241a	2,642a	2,941a
CT_5 - Conventional tillage with crop residues incorporation	148.40ab	142.44a	145.42ab	1,645bc	1,498ab	1,572b	3,078ab	2,678a	2,878a
CT_6 - Conventional tillage without crop residues	144.37b	134.15b	139.26b	1,452c	1,196b	1,324c	2,906b	2,262b	2,584b
S.Em. ±	**2.64**	**2.16**	**1.86**	**71**	**90**	**52**	**86**	**84**	**69**
F test **5 %**	*	*	*	*	*	*	*	*	*

NS: Non significant, *: Significant at 5 %

With respect to kapas weight, all the conservation tillage practices (CT_1, CT_2, CT_3 and CT_4) recorded significantly higher kapas weight (150.78, 150.72, 147.80 and 148.92 g $plant^{-1}$, respectively) over conventional tillage without crop residues (CT_6, 139.26 g $plan^{t-1}$) and they were on par with conventional tillage with crop residues incorporation (CT_5, 145. 42g $plant^{-1}$) (Table 3 and 4). Such differences with respect to yield components were reported earlier by Devkota*et al.,* (2013). The higher yields were mainly due to availability of potassium during boll development stages as applied potassium through cotton residues under optimum moisture conditions. In addition to this, the optimum condition resulted in higher uptake of N, P, K and other nutrients might have met the plant requirement of these nutrients for growth and development as evidenced by higher growth parameters resulting in higher yield attributes there by higher yield (Pervez *et al.,* 2008).

No tillage and BBF with both crop residue retention on the surface and incorporation treatments found more productive and profitable. Conservation tillage eliminates unsustainable part of conventional agricultural system and are crucial for sustaining productivity and conservation of natural resources under rainfed farming.

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